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ABSTRACT

This is a short paper about turns in skiing. It contrasts early and contemporary techniques and discusses biomechanical studies of rotation of limbs. It is stated that individual people's builds partially determine how they will accomplish turns. Diagrams are included. (CD)

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ROTATIONS OF LOWER LIMBS IN SKIING

Movements performed in skiing may be categorized as: up-down, fore-aft, side to side, and rotary. Hybrid forms of these categories exist. These movements affecting the displacement of the skier's center of gravity were investigated by Brandenburger (1964), Fukuoka (1971), and Sodeyama (1975). The rotary movements include medial (for right limb counter-clockwise twist) and lateral (for right limb clockwise twist) rotation of the lower limbs, as well as movements of the pelvis, chest, and upper limbs performed in the transverse plane (see Figure I). Rotation is a movement about long axis of a bone and is often confused with circumduction, which is a movement of a body part in a manner which describes a cone. In behavioral terms, the regions of the human body from which rotation may be derived were described by Pfeiffer (1970). Regrettably, little is know about torques exerted by the rotary effort of the lower extremities, nonetheless they are listed as a source of turning force in skiing for at least the past 15 years.

Early techniques utilized upper body projection in the direction of the intended turn: Schneider (1937), rotation of the trunk; Allais (1947), rotation of the head and shoulders; and Couttet (1960), rotation of the chest and pelvis helped by the outside arm.

Contemporary techniques use rotation of the lower extremity to trigger and propel ski turns: Commissione Scuole e Maestri de Sci (1971), "Rotazione degli arti inferiori", (rotation of lower extremities); Joubert (1970), "Braquage", (the movement produced in each leg at the pelvis by the rotators), and "Vissage", (pivoting of both legs and the skis through the support of the mass of the upper body); Osterreichischer Berufsschilerverband (1971), "Streckschub", (leg bending-stretching and simultaneous leg turning); Gamma (1971), "Oberschenkel-Knie", (thigh-knee articulation technique); and Abraham (1975), simultaneous-independent leg rotation.

Biomechanical studies which consider the muscular potential for turning of the limbs are few and often contradictory. Fick (1911), from investigation on cadavers concluded that lateral rotator muscles of the hips are three times stronger than medial rotators. Twardokens (1974), from investigations on living subjects, reported that variability tended to exist among subjects as ratios favoring medial or lateral rotation were observed. Some muscles of the lower limb were attributed diametrically opposite rotary functions by different researchers. Basmajian (1962), stated that "the quality of the research done in this region of the body has been spotty and many unwarranted conclusions have been made (p. 125)".

Traumatology of alpine skiing identified the tibia as the weakest link in the lower extremity. Asang (1972) found that properties of tibia (elastic twist $\approx 12^{o}$) between ages 20 and 60 remain nearly constant. To fracture the tibia through twisting, only 1/3 of the force required to produce a fracture through bending was needed.

To turn the lower limb against the pelvis, the muscular force may be derived from three regions of the human body: (1) leg/thigh muscles acting on the lower foot joint, (2) thigh/pelvis muscles acting on the knee joint, and (3) pelvis/lumbar muscles acting on the hip joint. Such breakdowns are made for descriptive purposes

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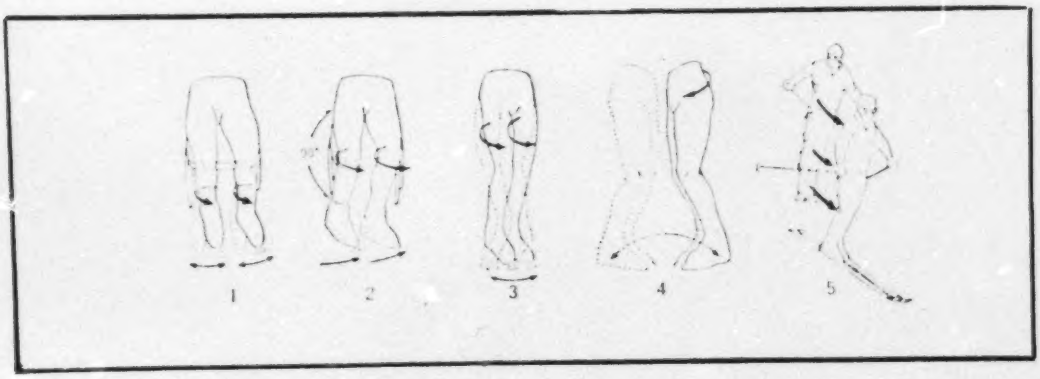

Fig. I

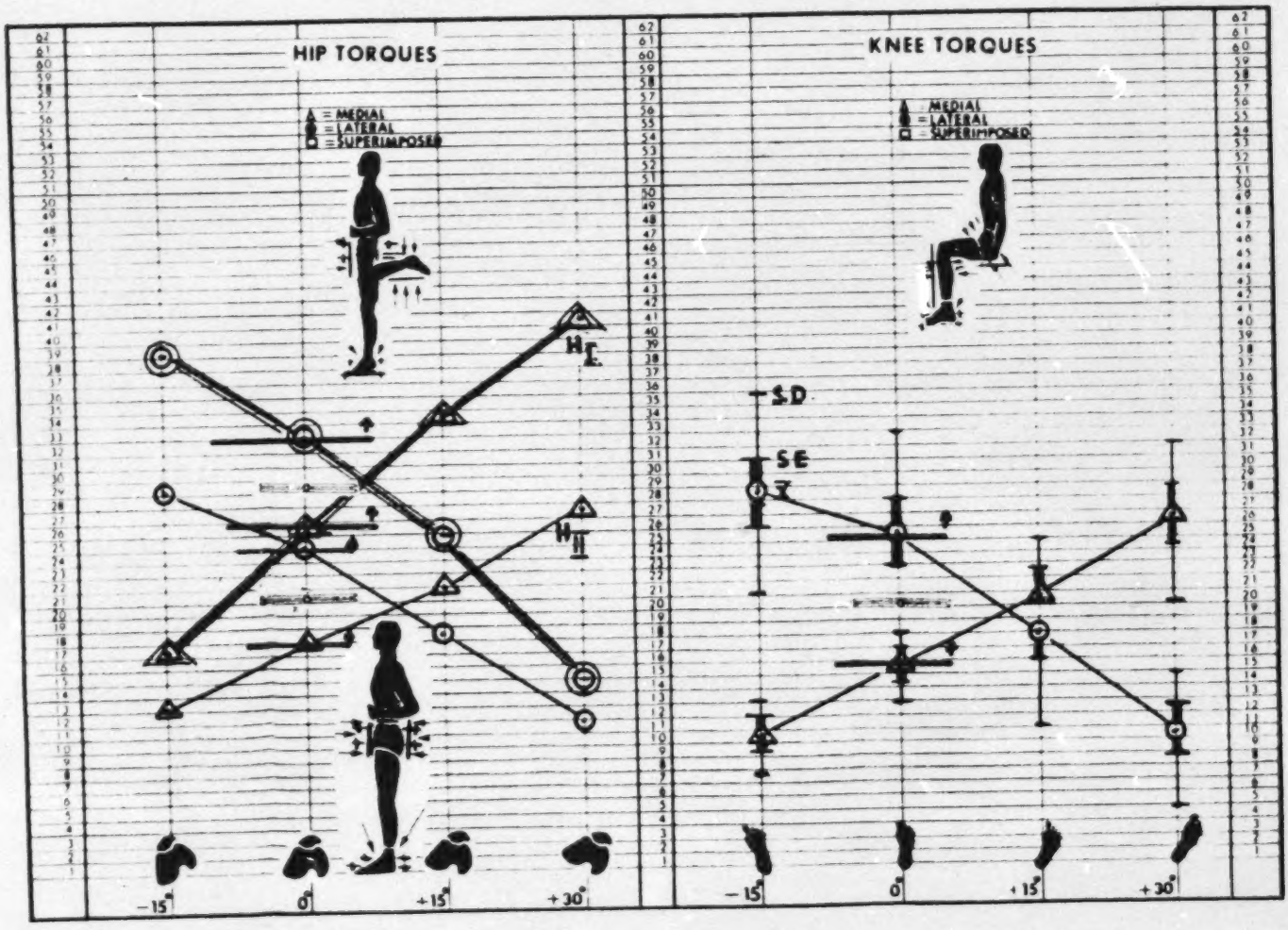

Fig. II

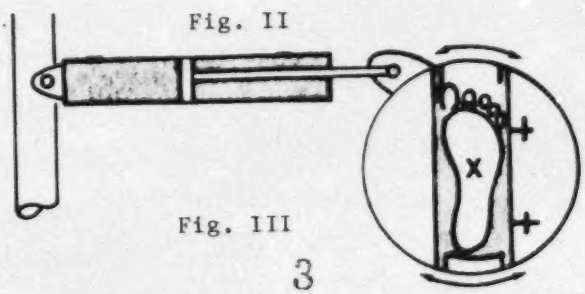

Fig. III

only ("complete isolation of a single movement in skiing is not feasible (Twardokens and Broten, 1971, p. 56)".

On the living subjects the torque could be measured only from the hip joint (Fig. I, 3), and from a combined effort of foot and knee joint (Fig. I, 1 and 2). The necessary cooperation of the knees and feet was recognized by Syndicat National Des Moniteurs Du Ski Francais (1967), as they stated, "physically the feet must work in the same way as the knees (p. 75)".

Average torques of the hip and knee joint are presented in Fig. II. Note that the 0^{o} angle may be considered analogous to the feet parallel position in initiation of ski turns (inside leg of a turn performs lateral rotation while the outside leg performs medial rotation). The 0^{o} torques denote larger scores for lateral rotation (inside leg) and lesser for medial rotation (outside leg). It should be remembered that these scores represent arithmetical averages computed from individuals whose ability to exert equal torques medially and laterally was between 0^{o} and $+15^{o}$ angles. In all individuals, however, the limb position in which the tested muscles were elongated recorded the largest foot-pound scores.

In discussion, one may point out that what is true of the torque study may not be equally true in ski turns. The ability to stabilize the upper body may modify or limit the use of force available from rotator muscles. In the domain of human measurements there are probably few, if any, people who would really qualify as average. However, research supporting this presentation seems to be in closer approximation to functional skiing movements than to classical anatomical studies.

Inside limb turn (lateral rotation) in skiing was documented by Kruckenhauser and Hoppichler (1968), as they observed that the needed skill for transition from snowplow turns to skidding was the active turning of the inside ski. Joubert (1970), analyzed activity of both legs in braquage and considers it a prerequisite for rapid student improvement and learning to ski parallel directly. Abraham (1975), listed inside leg steering as action adding powerful turning momentum to initiation of wedge, stem, step, and "parallel" turns. Empirical evidence for involvement of the inside leg in turning is provided by free style skiing. In standard teaching lateral rotation is still insufficiently explored (Twardokens, 1970). Large muscle groups available to produce turning in this direction find little use in our methodology.

Outside limb turn (lateral rotation) was described by nearly all technicians, however, rather as a conveyer of weight shifting and edging. The potential for turning of outside limbs in very wide snowplows may be near zero, it increases in parallel turns, and reaches considerable force in pre-turns and garlands because for more powerful medial rotation, more elongation of medial rotators is necessary. This could be achieved through turning the outside limb uphill, the pelvis downhill, or a combination of both. In standard maneuvers, elongation of lateral rotators seems to be unnecessary.

Both legs are involved in skiing, in some turns, simultaneously - in others, successively. One may surmise that individuals who are able to exert even maximal torque at 0^{o} angle are better endowed for simultaneous leg rotation, while individuals exerting uneven torque at 0^{o} are better endowed for independent leg rotation. Future research may investigate if such a correlation indeed exists. The rotator muscles are rarely exercised against resistance in ski conditioning programs (see proposed principle for exercising rotator muscles in Fig. III)which may be one reason for their frequent inability to respond effectively to the instructor's command: "Turn your legs!"

The list of muscles involved in turning of the lower extremity represents a survey of 40 authors who mention rotary actions of the hip muscles. Muscle groups whose functions have been generally accepted were separated from muscle groups which have been the subject of functional controversy (Twardokens, 1974).

Medial Rotation:	Lateral Rotation:	Controversial Group:
Gluteus Medius (a.f.)	Biceps Femoris	Adductor Bervis
Gluteus Minimus (a.f.)	Sartorius	Adductor Longus
Semimembranosus	Gluteus Maximus	Adductor Magnus
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Tensor Fascia Latae	Gluteus Minimus (p.f.)	Pectineus
	Gemelli (Sup. and Inf.)	Iliopsoas
	Obturators (ext. and int.)	Gluteus Medius (a.f.)
	Piriformis	
	Quadratus Femoris	

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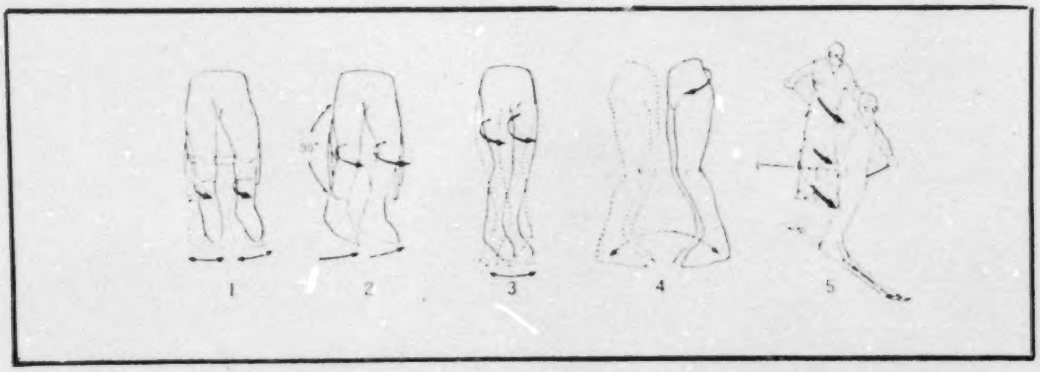
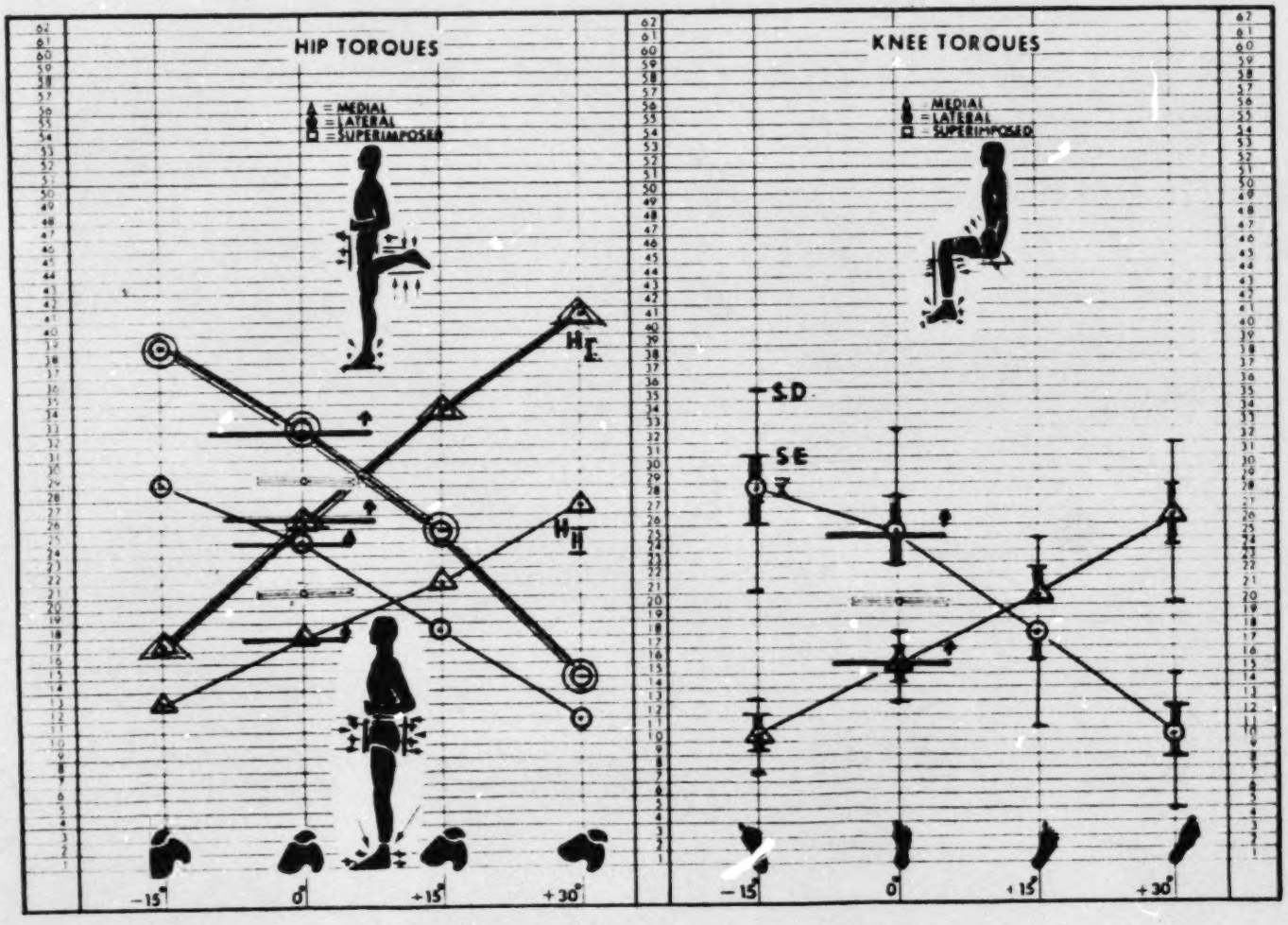


Fig. I



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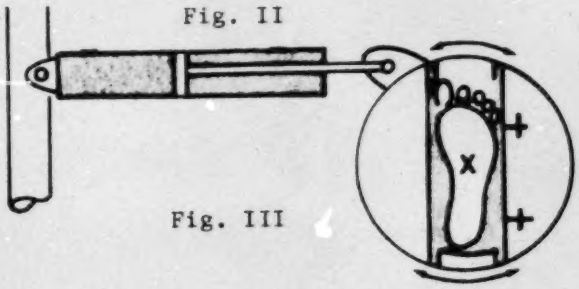

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